Nicolai A. Kryloff
7/12/07

Hole in the River:
A History of Groundwater
in the South Platte Valley, 1858-1969
[DRAFT]

Water moves underground. Beneath sheets of ancient shale, through gravel beds of elder rivers, its presence has long been regarded as mysterious. It moves unseen. Dowsers, or water witches, claim a special ability to auger its location; a court in Ohio once described it as "so secret, occult and concealed" that no set of laws could be applied to it.[1] Yet in many parts of the American West, extensive regional economies have become invested in groundwater extraction, with both farms and cities supplied by it. The valley of the South Platte River, home to Colorado's largest urban centers and most productive agricultural operations, is such a place.

In the early twentieth century, as groundwater's physical mysteries began to fade under scientific scrutiny, deeper paradoxes emerged from beneath the South Platte valley floor. In this region, water's relentless movement underground steadily eroded Colorado's approach to water administration, turning old maxims upside-down and creating new friction between water users. Ultimately, the movement of water caused human and natural systems to become entwined and entangled, resulting in unexpected opportunities and intractable difficulties for water users and managers alike. This historical account rests on three central assumptions. First, water itself was an active element of historical change, and so continues to be today. Second, differing human conceptions of groundwater's fundamental meaning also influenced its use and

[1] *Frazier v. Brown*, 12 Ohio 294, 311 (1861). For a historical account of dowsing, see Walker D. Wyman, *Witching for Water, Oil, Pipes, and Precious Metals: A Persistent Folk Belief from Frontier Days Down to the Present* (River Falls: University of Wisconsin Press, 1977).

management. Finally, human designs for managing groundwater were enmeshed in uncontrolled natural processes, and each influenced the other in unanticipated ways. This conceptual foundation helps to explain a complicated story – to understand how longstanding methods of western water management, which for more than a hundred years authored economic development, could somehow become inverted to obstruct the same goal;[2] to decipher how a discussion about resource management was transmuted into a battle over property rights; to fathom how farmers, both those using surface flows and those tapping groundwater, could be ruined by drought while standing above an underground reservoir filled with more water than Lake Powell.[3] The history of groundwater use in the South Platte valley is a search for explanations.

Groundwater in this region is fused by nature to a living surface stream; water moves freely between river and aquifer. This exchange – water's motion independent of human purposes – is at the heart of groundwater's history in the South Platte valley. Yet existing paradigms for water history have not fully appreciated the importance of this type of historical agency. Even the most prominent historians have focused on human manipulations of water, especially in terms of reclamation, dams, and diversions, and on

[2] Historians have recognized western water law as a driving force for economic development since the nineteenth century. Donald Pisani argued that prior appropriation sparked enterprise in the American West while stifling economic equality; Donald Worster argued that the system had a monopolistic effect, contributing to dangerous hierarchies of wealth and power. See Pisani, "Enterprise and Equity: A Critique of Western Water Law in the Nineteenth Century," *The Western Historical Quarterly* 18, no. 1 (January 1987): 15-37; and Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985).

[3] In 2006, groundwater users of 440 wells in the South Platte valley, some of whom had already planted crops, were forbidden by law to pump water for irrigation because surface rights were not adequately protected. By contrast, a study at Colorado State University found that severe drought in 2002 forced surface-water users to give up farming at a higher rate than groundwater users. See Marshall Frasier and Eric Schuck, "Coping with Natural and Institutional Drought," *Current Agriculture, Food & Resource Issues* 5 (2004): 119-130.
An acre-foot of water would cover an acre of land to a depth of one foot. The South Platte valley aquifer contains an estimated 25 million acre-feet; Lake Powell currently holds about 21.5 million, though its full capacity is higher. See Andrea Aiken et. al., eds., *The Colorado Ground-Water Atlas* (Lakewood, Colo.: Colorado Ground-Water Association, 2000), 23-27.

the social and environmental consequences of those endeavors. Norris Hundley, Jr., for example, emphasized the deleterious effects of conflicting local interests in reclamation projects, while Donald Pisani pointed to a lack of coordinated planning and governmental leadership as the main culprit for social and environmental costs. Even Donald Worster, who has articulated environmental agency in much of the rest of his work, portrayed water itself as largely a passive canvas for human action and social change in *Rivers of Empire.*[4] Although water is not alive, and its movements are usually predictable in terms of slope, gradient, and volume, water nevertheless follows its own agenda. Apart from human designs and control, its presence and motion can fluctuate with climate and weather patterns. It sometimes moves in unexpected ways: in the South Platte valley, it connects a river and an aquifer. Despite the fact that surface-water rights in Colorado were established separately from groundwater rights, the South Platte River and its underlying aquifer respected no such boundaries – they exchanged water naturally, creating a hydrological commons that the state's regulatory structure had not accounted for.[5] The historical agency of water carved its own identity into human affairs.[6]

---

[4] For an overview of the historiography of water in the American West, see Norris Hundley, Jr., "Water and the West in Historical Imagination," *Western Historical Quarterly* 27, no. 1 (Spring 1996): 4-31. Also see *Rivers of Empire: Water, Aridity, and the Growth of the American West.* New York: Pantheon Books, 1985. See also Worster, *The Wealth of Nature: Environmental History and the Ecological Imagination* (New York: Oxford University Press, 1993); Pisani, *Water, Land, and Law in the West: The Limits of Public Policy, 1850-1920* (Lawrence: University Press of Kansas, 1996); Hundley, *The Great Thirst: Californians and Water: A History*, rev. ed. (Berkeley: University of California Press, 2001).

[5] A similar kind of natural commons regime is analyzed by Mark Fiege in "The Weedy West: Mobile Nature, Boundaries, and Common Space in the Montana Landscape," *The Western Historical Quarterly 35*, no. 1 (2005): 22-48. Fiege postulated an "ecological commons" that defied regulation or private property schemes – weeds presented a mutual problem in Montana, tumbling through fences and across property lines, linking together land that was supposed to be separate. As in the South Platte valley, these schemes and regulations ultimately hindered the consistent management of shared environmental characteristics.

[6] The portrayal of water as an active historical element has never been applied to groundwater. Scholars such as John Opie, and Geoff Cunfer have studied deep aquifers such as the Ogallala, where water has little relation to surface flows and may be accurately characterized as a passive resource, something that can be "mined." In the South Platte valley aquifer, water's motion is more dynamic. In some historical studies involving water, inroads have been made toward a more inclusive model. For example, Richard White illustrated the hybrid characteristics of the Columbia River valley, arguing that although the river was

But human conceptions of water's meaning and purpose also influenced groundwater use in the South Platte valley. The interplay of opposing perspectives shaped attitudes about groundwater's proper use and management. In the 1930s, drought-stricken farmers, scrambling to save their crops, tapped common underground supplies with little restraint or regulation. By the 1950s, however, as depletions became undeniable in many places, most western states sought to control groundwater in order to conserve it. In Colorado, scientists and engineers regarded groundwater as a vulnerable resource that required protection to prolong its use, and they were among the first to call for state regulation. But while scientists saw primarily a physical resource in need of conservation, lawmakers encountered an abstract web of overlapping property rights – both groundwater rights that required recognition and definition, and established surface-water rights that demanded legal protection. Caught between these external perspectives were farmers, many of whom perceived access to groundwater in terms of economic survival. To produce irrigated cash crops such as sugar beets and corn, they sought to achieve local control over this vital part of their enterprise, while also recognizing the wide diversity of local conditions that standardized management constraints would overlook. They saw groundwater primarily as an economic necessity and sought to

---

altered substantially by people, its natural character also endured. Likewise, Mark Fiege has argued that people could not eradicate nature from western agricultural landscapes despite their intensive efforts at environmental mastery. Both studies emphasized the blurred boundaries between people and their natural surroundings, illustrating that society and environment do not function in isolation but rather in dialogue, each reshaping the other. See Fiege, *Irrigated Eden: The Making of an Agricultural Landscape in the American West* (Seattle: University of Washington Press, 1999); and White, *The Organic Machine: The Remaking of the Columbia River* (New York: Hill and Wang, 1995). For histories of groundwater in confined aquifers, see Geoff Cunfer, *On the Great Plains* (College Station: Texas A&M University Press, 2005); John Opie, *Ogallalla: Water for a Dry Land* (Lincoln: University of Nebraska Press, 1993); Theodore Steinberg, *Slide Mountain, or the Folly of Owning Nature* (Berkeley: University of California Press, 1995), 82-105. For a comparison of groundwater law across the west, see Robert G. Dunbar, "The Adaptation of Groundwater Control Institutions to the Arid West," *Agricultural History* 51 (1977): 677.

preserve local control over its use.[7] Collectively, these opposing perspectives of scientists, lawmakers, and farmers clashed and compromised with one another to shape groundwater's use and regulation in the region.

As groundwater was increasingly utilized and regulated, human-made systems of administration became entangled with the hydrological systems of the South Platte River and its aquifer, producing unexpected outcomes and strange difficulties. Ancient natural forces once shaped the river and aquifer, yet widespread irrigation changed the fundamental character of both. Later, as overall water use in the region expanded with increased access to groundwater, delicate balances between water use and availability remained possible under just the right combination of human and natural influences. But as regulations designed to preserve these tentative accommodations were debated and legislated, underlying hydrological systems worked to dissolve any clear-cut legal or administrative categories, confounding key principles of Colorado's water administration system. In the South Platte valley, clashing perspectives and natural conditions sculpted the use of groundwater, producing a series of fragile accommodations between people and their surroundings – a world made by humans and nature together.

Throughout most of its reaches, the South Platte River is a muddy agricultural workhorse, churning across Colorado and Nebraska for more than 400 miles. But its journey begins in melting snow. Starting high in the Rocky Mountains, it rushes through rugged valleys, merges with icy creeks, and spills onto the thirsty plains. There, it meanders – sometimes gushes – through the city of Denver, whose residents once panned

[7] The study of cognitive perceptions of water and its meaning represents another emergent strain in water history. For a comparison of abstract and subjective ways of looking at a river, see Linda Nash, "The Changing Experience of Nature: Historical Encounters with a Northwest River," *The Journal of American History* 86, no. 4 (March 2000): 1600-1629.

its banks for gold, but later used it as a municipal dump. Recently, the river's urban stretch has been remade into a flood-proof greenway, complete with wide swaths of open vegetation, bicycle trails, even a kayak park.[8] Flowing north through Denver, the river absorbs the Big Thompson and Poudre Rivers before taking an easterly turn. It then flows toward the state's northeastern corner some 150 miles away, irrigating along the way much of the state's most productive farmland.[9] The river finally enters Nebraska, later to mingle with the North Platte, Missouri, and eventually Mississippi Rivers. In all directions, the endless plains extend unbroken, flat as the sea. But this uniform landscape conceals the uneven contours of an earlier age.

Below the ground, the South Platte valley aquifer is more than 200 feet deep in places, containing more than 25 million acre feet of water. A mixture of sand, clay, and gravel, it sprawls beneath the flowing stream and its tributaries like a shadow, filling lost subterranean channels once carved by Pleistocene rivers. But its water is not ancient. In fact, the aquifer's vast subterranean storage is more the product of nineteenth-century farming than of continental uplifts and Ice Age glaciations. Unwittingly, people altered the aquifer and the river above, and these actions changed people and their institutions in return. At once ancient and recent, natural and artificial, this strange aquifer has strained the limits of the West's most venerable system of water management.

Above the aquifer's silent chambers, the South Platte River flows. Novelist James Michener once described it as "a sad, bewildering nothing of a river…a wandering

[8] The river's urban rehabilitation began in the 1960s. For an introduction, see Joe Shoemaker, *Returning the Platte to the People: A Story of A Unique Committee, the Platte River Development Committee* (Westminster, Colo.: Greenway Foundation, 1981).

[9] U.S. Environmental Protection Agency. *The South Platte River in Colorado* (Washington: U.S. Department of Agriculture, 1999).

afterthought, a useless irritation."[10] Denver's founders gave it no great respect – the offices of the *Rocky Mountain News* originally were built on stilts in the muddy bottoms of Cherry Creek as it emptied into the South Platte, its editor remarking in 1860 that he was "not yet inclined to believe the Indian claims that the whole settlement is subject to flood."[11] By 1864, he was convinced. That summer, the newspaper's 3000-pound press was swept downstream, along with the entire building and most of downtown Denver, in a massive torrent that killed twelve people and wreaked perhaps a million dollars worth of property damage.[12] Such volatility characterized not only the river itself, but also helped create the giant aquifer beneath it.

Roughly a million years ago, the ancestral South Platte developed drainage patterns similar to those evident today. Following a general continental uplift, the ancient river began to carve deep channels into the Tertiary sediments of the high plains east of the Rocky Mountains, down to the bedrock shale deposited by inland seas more than 80 million years prior. These channels – sometimes many miles wide and hundreds of feet deep in places – gradually filled with clay, sand, and gravel, called alluvium. Over time, erosion caused the river's slope to decrease, and more materials were gradually deposited. These were washed and rewashed as Ice Age glaciers froze and melted high in the mountains, leaving behind relatively clean beds of sand and gravel along the course of the South Platte and its ancient tributaries. By these processes, the geologic structure of an alluvial aquifer was formed.[13]

---

[10] James, A. Michener, *Centennial* (New York: Random House, 1974) 65.
[11] *Rocky Mountain News*, 1 August 1860.
[12] Robert L. Perkin, *The First Hundred Years: An Informal History of Denver and the Rocky Mountain News* (New York: Doubleday & Company, Inc. 1959), 209-225.
[13] L.J. Bjorklund and R.F. Brown, *Geology and Ground-Water Resources of the Lower South Platte River Valley between Hardin Colorado, and Paxton Nebraska* (Washington, D.C.: GPO, 1957); Morton

Today, the South Platte flows over this gravel bed, as do the other major rivers in eastern Colorado, each along its own channel of alluvium. Among these rivers, which include the Arkansas and Republican, the South Platte's aquifer is the largest, containing an estimated 25 million acre-feet of water. The river's average annual surface flow, by contrast, is roughly 1.4 million acre-feet.[14] In places, tongues of alluvium also underlie dry tributaries that once coursed with water. The South Platte alluvial aquifer is, unlike the vast Ogallala to the east, intimately connected to surface flows – water can easily seep into the aquifer from the South Platte River, or vice versa depending on the height of underground water levels. While the Ogallala is confined by impermeable materials and cannot be refilled in foreseeable human generations, the South Platte's aquifer is renewable. Like a giant sponge beneath a leaky faucet, it can dry out or become saturated depending on surface conditions.[15]

This water can also be extracted. The aquifer, an ancient, hidden water-bearing formation created by epic natural forces, has been altered by people. Yet for many years, its presence was virtually unknown. Above, the river's flow was intermittent – subject to great flooding, but often disappearing into the sand during summer months: "more of a quicksand than a river," recalled one early settler.[16] This unassuming watercourse had already witnessed one tremendous historical event. In 1858, a man named William Green

---

Bittinger, "Ground Water Management Vital to Comprehensive Development of River Basin Water Resources," *Colorado Farm and Home Research* 12, no. 4 (1962).

[14] An acre-foot of water would cover an acre of land to a depth of one foot. The South Platte River's annual surface flow is cited in P.K. Bash and R.A. Young, *The Role of Tributary Ground Water in Irrigated Crop Production in the South Platte Basin: Results from a Survey* (Fort Collins: Colorado Water Resources Research Institute, 1994).

[15] For historical accounts of groundwater use from the Ogallala aquifer in the Midwestern states, see Cunfer and Opie. For an account of Ogalalla use in Texas, see Donald E. Green, *Land of the Underground Rain: Irrigation on the Texas High Plains, 1910-1970* (Austin: University of Texas Press, 1973).

[16] Statement of Charles Huffsmith, 13. Box 26, Papers of Delph E. Carpenter and Family, Water Resources Archive, Colorado State University (hereafter DEC).

Russell fished a few bits of gold from a muddy tributary of the South Platte, setting off the greatest single mass migration in American history.[17] Farmers and miners alike poured into the valley in droves, and by 1861, water was being siphoned from all the principal streams in the river's upper reaches for mining and irrigation.[18] This activity was sanctioned by the newly formed Colorado Territory as a right "so universal and imperious that it claims recognition of the law."[19] By the time Colorado reached statehood in 1876, water was treated as a transferable public commodity.

The legal severance of water from land was a departure. In the East, following English common law, water and land were basically inseparable: owners of property bordering a lake or river had a right to use the adjoining water. Under this system, known in legal parlance as the Riparian Doctrine (derived from the Latin word *ripa*, meaning the bank of a stream), a watercourse was, in most cases, forbidden to be modified or diminished to the detriment of other riparian property owners. Shortages were shared equally by all affected landowners.[20]

A different system developed in California during 1849 gold rush. Streams were often inconveniently located for mining purposes: overlying a promising bed of gravel, or too distant from gold deposits to be useful. To solve either problem, water had to be redirected from its normal channel. It could then be treated as an independent property right, established by diversion and subsequent application, conceptually separate from the

[17] For an environmental history of the Colorado gold rush, see Elliott West, *The Contested Plains: Indians, Goldseekers, and the Rush to Colorado* (Lawrence: University of Kansas Press, 1998).
[18] Tom Cech, "Water Development and Management Along the South Platte River of Colorado," in *Water and Climate in the Western United States*, ed. William M. Lewis, Jr. (Boulder: University of Colorado Press, 2003), 153-159.
[19] *Yunker v. Nichols*, 1 Colo. 551 (1872). See also Gregory J. Hobbs, Jr., "The Role of Climate in Shaping Western Water Institutions," *University of Denver Water Law Review* (Fall 2003), 10.
[20] For a concise explanation of riparian water rights, see Robert Dunbar, *Forging New Rights in Western Waters* (Lincoln: University of Nebraska Press, 1983), 59-61.

underlying land. When there was not enough water for everyone (as was often the case in the crowded goldfields), rights were fulfilled according to their dates of priority: the earliest right received its full allotment first, then the second right, and so on until all rights were satisfied, or until no water remained. Thus, shortages were borne unequally by those with later rights, but the investments of early claimants were protected. This system, called the Doctrine of Prior Appropriation, was hotly contested in some California camps, marked by violence and contradictory court rulings.[21] But prior appropriation found a true champion in Colorado. Whereas California adopted a mixture of riparian principles and prior appropriation, Colorado proclaimed the purest priority system in the country: a strict code known as the Colorado Doctrine. Groundwater would become this system's greatest challenge.

The presence of underground water was recognized almost immediately by American farmers and settlers in the South Platte valley, even if it was not fully understood. As early as 1860s, freighters and cattle drivers carried shovels and scrapers to dig for water along the river during hot summer months, when the river would disappear into its deep gravel bed. Travelers sometimes sunk bottomless kegs or boxes into the dry riverbed to use as makeshift wells.[22] Although summer flows were generally more reliable near the mountains, farther onto the plains the South Platte often became intermittent in the summer. "It just soaked away," one traveler remembered, turning into a series of shallow pools "alive but standing," connected by no discernable surface flow.[23] Charles Lent, a farmer and ditch-rider who came to the valley in 1896,

[21] Donald J. Pisani, "Enterprise and Equity: A Critique of Western Water Law in the Nineteenth Century," *The Western Historical Quarterly* 18, no. 1 (January 1987): 15-37.
[22] Statement of George A. Hodgson, 3. Box 26, DEC.
[23] Statement of David Camp, 3. Box 26, DEC.

remembered unreliable summer flows near the turn of the century: "The river used to be so low," he recalled, "we could cross it with just a common pair of Sunday shoes on without getting your feet wet."[24] In effect, the river would simply sink away into the vast aquifer below.

Unbeknownst to the early settlers, human activity had already begun to change the character of both the river and the aquifer beneath it. In the upper reaches of the South Platte, heavy farmland irrigation was causing what one contemporary called a "revolution in natural conditions."[25] This revolution was due to seepage water, an occurrence which was articulated scientifically for the first time in the valley by L.G. Carpenter, a researcher at Colorado's State Agricultural College in Fort Collins. In 1897, Carpenter posited a "filling of the subsoil" by irrigation runoff near the valley. Water levels had risen in some places by forty to sixty feet, and were continuing to rise.[26] Before irrigation came to the region, spring floodwaters commonly surged down the South Platte. But beginning in the 1870s, irrigation companies built reservoirs to capture and save these flows. When farmers applied this storage water to their crops, a substantial volume soaked into the porous soil rather than flowing away as floodwater, evaporating, or being absorbed by plants. This seepage eventually reemerged in the river downstream, causing volumes in the South Platte and its tributaries to rise. Most important to irrigators, the flows became increasingly regular during late summer and autumn, when the river historically had been lowest – and when many crops most needed water. Carpenter predicted these flows would only increase, valuing them at more than two million dollars

[24] Statement of Charles H. Lent, 1-2. Box 26, DEC.
[25] Statement of Charles C. Huffsmith, 16. Box 26, DEC.
[26] L.G. Carpenter, *Seepage or Return Waters from Irrigation*, The State Agricultural College Experiment Station, Bulletin 33 (Fort Collins: Colorado Agricultural College, January 1896), 4, 51.

and counting. The river was rising, and irrigators filed legal claims to the additional water.

Farmers were not oblivious to the river's change. Henry DeVotie, farmer and president of a ditch company near Greeley, noticed autumn flows steadily increasing downstream from his farm following years of irrigation and reservoir construction on the South Platte. "The subsoil is saturated," he asserted in 1922, "and a large amount now gets back to the river, making the river flow more uniform than ever before." Here was an intersection of human and natural conditions: Farmers responded to lack of rainfall by irrigating their crops, and application of irrigation water, in turn, changed the river's essential characteristics. The altered flow patterns were recorded by cottonwoods – "a rank hearty growth," a cattleman observed in 1918, had occurred all the way from Denver to the state line, with the trees becoming smaller and younger proceeding downstream.[27] These additional flows served as the basis for new water rights. As availability of water increased, human use expanded accordingly.

Early farmers also displayed an awareness of conditions below the earth. DeVotie noted that "irrigation not only assists plant growth, but also serves the purpose of underground storage of water."[28] Some farmers were tapping this underground storage even before the turn of the century. In 1889, E.F. Hurdle drilled the first recorded irrigation well in the South Platte basin, using a steam engine to operate the pump. Within a few years, a neighbor sought an injunction against him for diminishing the flow of a nearby creek. But the court ruled in Hurdle's favor. Despite finding a probable connection between groundwater and creek water, allegations of the well's detrimental

[27] Hodgson, 3. Box 26, DEC.
[28] Statement of Henry M. DeVotie, 20-23. Box 26, DEC

impacts were "vague, conflicting, and indefinite."[29] The case established the legal precedent that groundwater was somehow connected to surface flows, but it also exposed the difficulty of demonstrating specific injuries in court based on that relationship.

Moreover, Hurdle's case revealed a basic awareness of large volumes of usable water underground. As this water became more accessible in the coming decades, agriculture in the region expanded, becoming increasingly dependent upon underground supplies. But signs of stress also emerged – some farms became pocked by dry wells, while other pumps surged or sputtered, indicating that something was wrong underground. Increased pumping strained the established accommodation between water use and availability, setting off alarms within the scientific community.

One of Colorado's foremost groundwater researchers was William E. Code. He began work as an irrigation engineer at the state's Agricultural Experiment Station in 1928, and for the next thirty years he devoted his career to groundwater investigations. His commitment to data collection along the South Platte and other agriculturally productive river basins was unmatched by any researcher before him. In the spring of 1944, as war raged across three continents and scientists worked to split the atom in Los Alamos, Code scoured the backroads of rural Colorado, measuring water in a cold, silent aquifer. On May 22, he set out from Fort Collins armed with a Kodachrome camera. Driving past fields of alfalfa, he stopped frequently to visit farmers, photographing their wells and recording local water-levels. He helped some irrigators repair broken pump motors; others he joined for ranch-style barbeques, all while discussing equipment and pumping operations. He braved sudden thunderstorms and washed-out roads, observed

[29] *McClellan v. Hurdle*, 3 Colo. App. 430 (1893).

the work of a well-digger and a water witch, and interviewed a bank executive who was lending money for irrigation pumps and drilling.[30] For Code, the journey was part of an ongoing ritual – over time, his inventories grew to include thousands of wells, making him the region's leading scientific authority on the subject.

But Code was alarmed by trends he saw in his hydrographic charts. These saw-toothed patterns charted water-level readings at various wells, with each jagged point representing a fluctuation in the water table through spikes and troughs. Typically, levels dropped during the irrigation season and recovered as groundwater recharged through precipitation, irrigation seepage, and the South Platte's flow. But in certain areas, the overall trajectories pointed noticeably downward, indicating that groundwater extraction exceeded recharge in those locales. Already, Code had tried to dispel the "unfortunate idea" that groundwater was inexhaustible, warning that dropping water tables meant a reduction in well capacities, potentially causing many to go completely dry. At the same time, he was attuned to the considerable investments many farmers had made in groundwater. "An irrigation well is something more than a hole in the ground," he wrote; rather, it was a considerable investment, often made on credit.[31] Code feared an economic crisis would follow widespread groundwater depletion.

To protect both water-tables and investments, Code called for legislative action. He pointed to examples of severe groundwater depletions in California and Arizona, urging Colorado's lawmakers to choose a different path.[32] The connection between groundwater and surface water was widely recognized. A U.S. Geological Survey report

[30] Code recorded his experiences in a 1944 field book entitled "Ground Water Investigations." Box 8, Groundwater Data Collection, Water Resources Archive, Colorado State University (hereafter GDC).
[31] W.E. Code, "Pumping Moves Eastward," *Western Farm Life*, 1 June 1937.
[32] W.E. Code, "Colorado Needs Ground-Water Legislation," c1954. Box 16, GDC.

in 1940 mentioned that where wells operated near the South Platte, surface flows were surely reduced: "in those areas," the report affirmed, "the water levels are being maintained at the expense of the river."[33] While acknowledging this connection, Code's overriding concern continued to be the conservation of an underground water supply.[34] In essence, he sought to avoid a disruption of the existing accommodation between groundwater use and its availability, worrying that haphazard exploitation would lead to rapid depletion. Like many conservation-minded scientists of his era, Code advocated regulation of this natural resource largely to ensure its continued availability for future use.

Environmental conditions encouraged and accelerated well-drilling. From 1930 to 1940, a savage drought seared Colorado and most of the West – the most widespread and longest lasting in the state's history.[35] Not coincidentally, irrigation wells also proliferated dramatically during this time, from 654 statewide to nearly 3,000 by the decade's end, with nearly two-thirds located in the South Platte valley. The increase was no accident. Even before the drought, advisors at a northern Colorado economic conference recommended "that pumping from wells be encouraged as a supplemental water supply."[36] As the drought intensified, the South Platte's flows dwindled alarmingly, and farmers looked to save their crops.[37] Wells offered abundant water in a time of short supply.

---

[33] W.N. White and C.V. Theis, "Proposed ground-water investigations in the drainage basins of South Platte, Arkansas, and Republican Rivers in eastern Colorado," (United States Department of the Interior Geological Survey, August 1940), 15. Box 15, GDC.
[34] W.E. Code, "Use of Groundwater for Irrigation," *Western Farm Life*, 15 January 1948.
[35] Thomas B. McKee et al., *A History of Drought in Colorado: Lessons Learned and What Lies Ahead* (Fort Collins: Colorado Water Resources Research Institute, 2000), 15.
[36] "An Agricultural Program for the Irrigated Region of Northern Colorado," 1930. Box 73, Colorado State University Extension Collection (hereafter EXT).
[37] White and Theis, 5. Box 15, GDC.

But pump irrigation did not come without problems. In addition to depleting groundwater supplies, wells captured seepage water that was moving toward irrigation canals and the South Platte. Some farmers objected that surface-water rights were being interfered with. Code concluded that because groundwater moved so slowly (perhaps three miles a year, he calculated, depending on local conditions), pumping had not greatly impacted surface flows.[38] Nevertheless, J.M. Dille of the Northern Colorado Water Conservancy District noted in 1942 that "complaints have been loud" among surface-water irrigators. Strangely, however, no litigation had materialized. "Many irrigation men are on both horns of the dilemma," he explained to a Denver audience – in other words, many surface-water irrigators in the valley had wells of their own.[39] In fact, Code calculated in 1943 that fully 82 percent of existing wells were operated in conjunction with surface rights. Despite an acknowledged correlation between the South Platte and its underground water, the overlapping use of these two sources dampened litigation among farmers.

As drought subsided by the 1940s, several developments sustained and even increased groundwater use. With the onset of World War II, farmers ramped up crop production to supply the American war effort. Along the South Platte, an agricultural planning committee in 1944 emphasized the necessity of high yields, recommending that irrigation pumps be run on a 24-hour basis "for economical use of water."[40] After the war, well-drilling continued as a form of drought insurance – if the rains again vanished, farmers wanted to be prepared.[41] Additionally, groundwater irrigation offered at least two

[38] W.E. Code, "Does Irrigation Pumping Affect Stream Flow?" *Western Farm Life*, 1 June 1938.
[39] J.M. Dille, "Irrigation Problems in Northern Colorado," October 1942. Box 27, DEC.
[40] "Good Farming Practices in Morgan County," 1944. Box 73, EXT.
[41] W.E. Code "Pumping for Irrigation," *The Western Farm Life* 49, no. 2 (1947).

distinct advantages over surface supplies. First, its availability was not immediately affected by a sudden absence of precipitation, and second, it was available precisely when and where a farmer needed it. This second advantage was especially important in places such as Prospect Valley, where surface irrigation was inefficient. Along this tributary of the South Platte, ditch water was unreliable and was allotted on a rotational basis. A farmer might not need water when his turn came to use it; other times, it might be unavailable when his crops needed it most. Groundwater irrigation solved this problem by providing water on demand, and Prospect Valley farmers embraced the technique fully. Some even sold surface rights to finance down-payments on wells.[42] Use of underground water both provided protection against drought and offered farmers greater control over the timing and application of irrigation water, increasing its popularity among South Platte farmers.

But these characteristics alone were insufficient to fuel the boom – technology also played an important role. Centrifugal pumps, built in England as early as 1754, underwent a series of revisions in the early 1900s to increase their efficiency. Improved rotary drills soon followed, allowing the wider bore necessary to install improved pumps.[43] Oil and gasoline gradually replaced steam power, and by the 1930s, rebuilt automobile engines were driving high-speed pumping equipment.[44] As late as 1957, tractors still powered nearly a fifth of pumps in the South Platte basin.[45] But there were cheaper alternatives. High-speed diesel engines were introduced in the late 1930s, providing efficiency at about a quarter the fuel consumption of gasoline. Still, the initial

[42] W.E. Code, "Pumping in Prospect Valley," *Western Farm Life*, 1 May 1938.
[43] For a thorough description of centrifugal pump and rotary drill technology, see Green, *Land of the Underground Rain,* 38-61.
[44] Green, 126-127.
[45] Bjorklund and Brown, 2.

cost of drilling wells and installing pumps was formidable.[46] But power costs soon dropped throughout the West, pushing the number of wells even higher.

Electrification was part of a national vision. Since World War I, scientists and government officials had seen in electricity the potential for revolutionary social changes: an end to congested urban slums and coal-fired factories, replaced by a revitalized countryside where clean hydroelectric power could energize decentralized industries with the flip of a switch.[47] In 1935, the federal government created the Rural Electrification Administration to finance loans for local cooperatives, which would then provide electricity to remote areas.[48] When Morgan County Rural Electric arrived in the South Platte valley in 1938, pump irrigators were targeted to help finance the endeavor, thereby increasing the region's reliance on groundwater. Code saw the connection between pumps and electrification almost immediately. In 1936 local petitioners near the Wyoming border hired him to investigate pumping possibilities in their own area. "Should pumping for irrigation be found feasible," Code reported, "the load on the lines would be greatly increased and would favor the building of lines which otherwise would not be economically possible."[49] Pump irrigation, powered by electricity, could make rural electrification in northern Colorado a reality.

---

[46] Code estimated in 1937 that pumping equipment alone would cost an irrigator between $4,000 and $5,000. W.E. Code, "Pumping Moves Eastward," *Western Farm Life*, 1 June 1937.

[47] Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970* (New York: Viking, 1989), 298-309; Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: The Johns Hopkins University Press, 1983).

[48] Harry Slattery, *Rural America Lights Up: The Story of Rural Electrification* (Washington: National Home Library Foundation, 1940).

[49] W.E. Code to L.V. Toyne, "Confidential report on reconnaissance survey of rural electrification in an area in Weld County in which the towns of Hereford and Grover are located," 1936. Box 14, GDC.

In the South Platte valley, this pairing of pumps and electric power was extremely successful. By 1943, sixty percent of pumps in the region ran on electric power.[50] "Colorado's power distribution companies agree that the state's pump-irrigation farmers are pretty good customers," proclaimed *Colorado Rural Electric News*, citing that pumps used enough kilowatt hours in one year to supply a city of 30,000 people for twenty-one months.[51] Rural electric companies fostered groundwater use by reducing rates and encouraging farmers: groundwater irrigation, declared the *Rural Electric News* in 1955, "should become a habit, not just something to be resorted to only when crops are threatened by dry spells."[52] By 1959, most irrigation pumps in the valley had converted to electricity.[53]

Other technological elements melded with natural drought in surprising ways to further encourage groundwater use. The Colorado-Big Thompson project, among the largest federal reclamation projects in the West, was launched in 1938 to protect existing irrigators from drought in the South Platte basin. Using a network of reservoirs and tunnels, the project took water from west of the continental divide, transferred it under the Rocky Mountains, and spread it onto the irrigated plains of eastern Colorado. Originally conceived as a water-supply plan, defense promoters advocated its use as a provider of hydroelectric power.[54] Ultimately, the project's generating capacity furnished

---

[50] W.E. Code, *Use of Ground Water for Irrigation in the South Platte Valley of Colorado*, Colorado Agricultural Experiment Station, Bulletin 483 (Fort Collins: Colorado State College, September 1943), 5.
[51] *Colorado Rural Electric News*, July 1963.
[52] *Colorado Rural Electric News*, May 1955.
[53] Edward J. Farmer, "A Study of the Effect of Ground Water Law on Pumping in the Bijou Bain," (M.A. thesis, Colorado State University, 1960), 10. Farmer estimated that 5200 total wells were operating in the valley by 1959. The same year, Paul A. Schneider, Jr. of the District Engineer's Office calculated a total of 5185 wells in the valley running on electricity. Schneider to Morton Bittinger, "Recharge Evaluations of the South Platte." Box 12, GDC.
[54] Daniel Tyler, *The Last Water Hole in the West: The Colorado-Big Thompson Project and the Northern Colorado Water Conservancy District*. Niwot, Colo.: University Press of Colorado, 1992.

electricity to rural cooperatives in the South Platte valley, which in turn sold it to pump irrigators.[55] This new power source coincided with the arrival of center-pivot irrigation, patented in 1952 by Coloradoan Frank Zybach. His system consisted of elevated pipes and nozzles, attached to wheeled towers, which rotated around pivots like the hands of a clock. The invention allowed for irrigation on hilly and uneven land, which could not be reached by ditches without costly leveling.[56] This system, enlivened by electricity, combined with pump irrigation to bring more than 30,000 acres of new land into production by 1960.[57] At the same time, however, water from the Colorado-Big Thompson project masked the effect of wells on the flowing river, offsetting the expected reductions in seepage water caused by pumping.[58] In essence, the addition of this trans-mountain water stabilized surface flows while it encouraged groundwater use by supplying cheap electricity. These oppositional yet complimentary influences preserved a tentative accommodation between water use and availability, even as groundwater use and irrigated acreage expanded. Simultaneously, however, the balance was being disrupted by declining water tables in groundwater-reliant areas.

Among the areas most threatened by depletion in the South Platte valley was the Bijou Basin, located along one of the river's typically dry southern tributaries. Farmers in the region were almost entirely dependent on groundwater for irrigation. Located several

---

[55] *Colorado Rural Electric News*, "Electricity Sold from Colorado-Big Thompson Project Boosts Economy," August 1963. Also see J.M. Dille, *Irrigation in Morgan County* (Fort Morgan: Farmers State Bank, 1960), 50.

[56] *Colorado Rural Electric News,* August 1963. Also Thomas Cech and Andy Jones, *Colorado Water Law for Non-Lawyers* (unpublished manuscript in possession of the author), 27.

[57] J.M. Dille, *Irrigation in Morgan County* (Fort Morgan: Farmers State Bank, 1960), 51-52. However, irrigated acreage was already expanding in the valley before electrification arrived. See White and Theis, 9. Box 15, GDC.

[58] For more on the "masking" effect of water from the Colorado-Big Thompson project, see Lawrence J. MacDonnell, "Colorado's Law of Underground Water: A Look at the South Platte Basin and Beyond." *University of Colorado Law Review* 59, no. 3 (Summer 1988): 579-625.

miles south of the flowing river, the underlying gravels recharged slowly. By 1956, water tables had fallen by as much as 30 feet, reducing the capacity of most wells and causing some to go dry altogether.[59] The basin was a compelling example of the depletion that alarmed Code. He predicted farmers in such a region would agree that "control in some form is needed among users from a limited source."[60] But while scientists and engineers viewed groundwater issues from the angle of resource management, farmers had a much different perspective. They conceived of the water beneath them in terms of economic survival and prosperity. Furthermore, they were attuned to the land's broad diversity of physical conditions, making them wary of any standardized regulations from outside.[61] Private investments collided with resource preservation, together contributing to the progression of groundwater's use in the basin.

Resistance among some farmers to scientific valuations was not new. As early as 1942, groundwater studies were proposed for the area. But "many local men are opposed to that," according to one expert. "They say it would be just college theories."[62] But in 1956, researchers from Colorado State University – formerly the State Agricultural College – conducted extensive economic and engineering surveys. At times, they encountered suspicion among farmers, noting that "many were cautious, and reluctant to provide the information sought."[63] But the researchers were determined to gauge farmers' opinions about various types of proposed regulation for their area. Confidential interviews and surveys recorded the attitudes and opinions of these people most

[59] Farmer, 13-14, 78-88.
[60] W.E. Code, "Colorado Needs Ground-Water Legislation," c1954. Box 16, GDC.
[61] James C. Scott addresses the pitfalls of applying scientific and legal abstractions to complex systems in *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998). Scott points out that standardization, by focusing only on certain criteria within a landscape, can externalize and overlook elements most critical to the people who live there.
[62] J.M. Dille, "Irrigation Problems in Northern Colorado," October 1942. Box 27, DEC.
[63] Farmer, 74-75.

intimately knowledgeable about the daily experience of groundwater irrigation. Their lack of solidarity on many issues pointed to the individualistic character of groundwater use at the time. While surface-water users had been associated with cooperative endeavors since practically the beginning of irrigation – ditch companies, irrigation districts, reclamation projects – groundwater users had no such ties, needing only to bore a shaft through their own land and install a pump. This individualism reflected the cacophony of opinions captured by researchers' interviews.

Despite a lack of agreement on many points, certain refrains rang clear. While researchers focused mainly on resource depletion, many farmers saw underground water as part of an economic investment. "The land is worthless without the water," one said. "We have paid so much for what's on top," echoed another, "we need what's underneath to make a decent living." Similar language recurred throughout the interviews: "I bought the land because the water was there, and I gave the price for not one, but both." In all, 70 percent said landowners should control the water underneath their soil.[64] This attitude was not simply a manifestation of ignorance or insatiable greed. Groundwater irrigation was a costly enterprise that often required substantial credit to initiate. For many farmers, loss of groundwater would mean insurmountable debt and financial ruin. Loss of control over their wells would amount to losing a job and a home all at once, while being saddled with mountainous debt on top. In contrast to scientists who advocated collective management to prevent resource depletion, farmers more often conceptualized the control of groundwater as the lynchpin to their investments and livelihoods.

Most tellingly, groundwater users in the Bijou Basin emphasized a broad diversity of local conditions, not easily reduced to uniform rules or regulations. Intimately familiar

[64] Farmer, 101-105.

with the land on which they farmed and lived, irrigators pointed out incongruities not accounted for by standardized legal propositions. They especially emphasized differences in crops and soils: "The sandhill farmer does not farm his land by choice, but by necessity," one commented. "He should not be penalized or otherwise discriminated against merely because he is on marginal land."[65] Similar objections were cited against proposed rules for well-spacing: "Topography limits well locations," another said, "…a fair distance in one place would be unfair in another."[66] If regulations were inevitable, most farmers favored at least some degree of local control "to take account of dissimilarities."[67] In all, nearly 80 percent of respondents advocated purely local administration of groundwater resources, and 94 percent wanted at least some local involvement.[68] If regulation was necessary, farmers sought a flexible system that would account for this diversity of natural conditions.

But these attitudes did nothing to reverse groundwater depletions. By conceptualizing the aquifer beneath them as a chain of individual investments, no matter how critical to their economic survival, most farmers failed to account for its connections to a larger hydrological system. Moreover, disparities in local conditions complicated any search for equitable management. By encouraging pumping to continue in spite of depletion, these attitudes threatened to upset the tentative balance between water use and supply. Code predicted a "dark and discouraging" future for regions where groundwater

[65] Farmer, 96.
[66] Farmer, 91.
[67] Farmer, 98.
[68] Farmer, 105.

depletion was not regulated.[69] The state's first meaningful groundwater legislation was an attempt to reverse this trend.

Colorado was one of the last western states to pass groundwater legislation. Former State Engineer M.C. Hinderlider suggested the state's legislative tardiness involved overlapping use of groundwater and surface water: "Well owners in various sections of the State are also owners of surface rights," he commented, "and have interests on both sides of the question."[70] The delay was perhaps also a consequence of the state's own success in developing its surface supplies so thoroughly, and providing trans-mountain water to supplement them. In developing statutory groundwater laws, New Mexico led the way in 1931, with most other states following suit in the 1940s and 50s. California struck its own path, cobbling together a system from judicial decisions dating back to the early 1900s.[71] Colorado's legal community sought to avoid this route, favoring "water administration by law, and not law by administration," one attorney quipped.[72] In fact, the Colorado Bar Association had attempted a comprehensive bill by 1946, but it was scuttled amid disagreements within the drafting committee. In 1952, a bill regulating well drilling was defeated by the legislature but returned in amended form the following year. In 1953, a small-scale act was passed with practically no debate, requiring little more than the licensing of well-drillers.[73] Two years later, a Senate

[69] W.E. Code, "Time to Build Legal Skeleton," *Denver Post*, 27 February 1957.
[70] M.C. Hinderlider, "Groundwater Problems of My State," undated. MSS 312, Box 8, Stephen H. Hart Library, Colorado State Historical Society.
[71] Robert G. Dunbar, "The Adaptation of Groundwater Control Institutions to the Arid West," *Agricultural History* 51 (1977): 662-680.
[72] "Water Battle Launched," *Rocky Mountain News*, 3 February 1963.
[73] W.E. Code, "Underground Water," *Rancher & Farmer*, 22 January 1955. See also John H. Cuykendall, "Administration of Colorado Groundwater Law," c1960. Box 16, GDC.

groundwater bill fell short by two votes, leaving a pervasive feeling that Colorado's legal code was falling desperately behind.[74]

By this time, more than five thousand wells – nobody was sure exactly how many – operated throughout Colorado with virtually no oversight. By the 1950s, however, the call for legislative action grew louder. Engineers such as Code rallied support: "To delay would only cause a bad situation to grow worse," he wrote in 1957 in the *Denver Post*. Meanwhile, new droughts strained the unclear relationship between surface-water rights and underground water. Ditch irrigators, Code wrote, were "extremely unhappy" to see their flows dwindle away while irrigation wells, governed by no statute, continued to pump freely. Lack of legislation, he argued, jeopardized everyone's rights.[75] Other experts concurred – State Engineer J.E. Whitten remarked "the longer we delay, the further afield we are going in this connection."[76] But among lawmakers, there was little consensus on how to proceed: "Party lines are out the window on underground water," one reporter wrote. "So are the usual sectional alliances." Although most legislators agreed on the need for groundwater regulation, they disagreed on what shape it should take.[77]

In the United States, four basic legal frameworks existed for governing groundwater use. The oldest, called the English Rule, recognized absolute ownership of land and everything below it. A modified version called the American Rule was adopted in some eastern states – water was still the property of overlying landowners, but wasteful use causing injury to other users was forbidden. A third format, the California

[74] Dunbar, *Forging New Rights in Western Waters*, 181-2.
[75] Code, "Time to Build Legal Skeleton," *Denver Post*, 27 February 1957.
[76] Legislative Council Subcommittee on Water Problems, "Report to General Assembly," February 1955. Box 16, GDC.
[77] "Tax Speedup Bill Passed by Senate" *Fort Collins Coloradoan*, 12 May 1957.

Doctrine, recognized groundwater rights as mutually correlated – each landowner was entitled to use a fair portion of the entire source, determined by the courts, and would have to share depletions proportionally. Finally, the Doctrine of Prior Appropriation severed groundwater from landownership altogether, allotting it on a first-come, first-served basis in any amount that could be extracted and put to use.[78] Colorado courts had several times ruled groundwater "tributary" to flowing streams, which seemed to indicate a leaning toward prior appropriation, which already governed surface rights.[79] But the picture was clouded by a district court in the San Luis Valley of southern Colorado, which ruled in 1953 that some groundwater use could be based on landownership.[80] Amid confusion and dissension, lawmakers made a disjointed effort to forge a workable groundwater law.

The 1957 Ground Water Act was a legislative Frankenstein. One commentator feared more than two dozen revisions would "amend it to death" before it was ever passed.[81] At issue was a basic question of ownership: "Is underground water the property of the people of Colorado or does the groundwater under your farm belong strictly to you?" asked writers of Colorado's *Rancher & Farmer*.[82] The question was more than academic. By 1956, pumps irrigated more than a million acres of farmland. In addition, groundwater supplied residents of more than a hundred towns east of the Rocky Mountains.[83] Opponents of public ownership warned that neighboring states could enjoin Colorado's wells. "If we tie all of our well water to live streams," Gov. Ed Johnson

[78] Edward J. Farmer, *Colorado's Ground Water Problems: Water and the Law*, Colorado State University Experiment Station, Bulletin 505-S (Fort Collins: Colorado State University, January 1960).
[79] *McClellan v. Hurdle*; *Safranek v. Town of Limon*, 123 Colo. 330 (1951).
[80] "Groundwater Use by Landowner OK," *Fort Collins Coloradoan*, 19 June 1953.
[81] "Plea of Ignorance on Water is No Alibi," *Denver Post*, 14 March 1957.
[82] "Who Owns Groundwater," *Colorado Rancher & Farmer*, December 1955.
[83] "Colorado's Next Water War," *Denver Post*, 18 November 1956.

warned, "the citizens of the lower states will have every right to demand that the operation of our wells cease."[84] Advocates countered that public ownership was necessary to integrate groundwater use into existing water law: "Don't be misled that the appropriation principle will take something away from you," urged Sen. Ranger Rogers.[85] But if older surface-water rights could shut down wells in times of shortage, argued Sen. Ted Gill, prior appropriation would be "a one way ticket back to thirty years ago, and no possible way to make reasonable use of this mammoth underground reservoir."[86] Other opponents pointed out that since many wells were drilled on loans, any policy disrupting them could "destroy the agricultural economy of the state."[87] In this contentious atmosphere, lawmakers settled on a pale compromise.

The only meaningful effect of the 1957 Act was to catalogue most of the state's wells by requiring permits. In this way, state administrators could at least account for groundwater use, even if fundamental questions remained unanswered. The act also created an eight-member Ground Water Commission, which could restrict groundwater use in any area it designated as critical. But the provision contained a loophole allowing residents of "critical" areas to overturn the designation through an elected board. The new law was first tested in the Bijou Basin, which was designated as a Tentatively Critical Groundwater District in 1958. Residents faced a choice between local candidates: those immediately opposed to restrictions, and those who advocated further study. Tensions heightened as voting day approached. State Ground Water Commission secretary George Colburn requested police presence from the governor, citing "direct and implied threats

[84] "Johnson Backs Gill Plan for Underground Water," *Fort Collins Coloradoan*, 13 December 1956.
[85] "Who Owns Groundwater," *Rancher & Farmer*, December 1955.
[86] "Opposition to Underground Water Measure," *Fort Morgan Times*, 16 March 1955.
[87] "Kelly Speaks Against Well Control Scheme," *Greeley Tribune*, 24 February 1955.

that the election would be interfered with."[88] But on March 10, 1958, no violence was reported, and the election turned into a landslide against the designation. "The overwhelming majority of legal voters in electing this board expressed their wishes at the polls," the *Fort Morgan Times* reported. "Land owners treasure their independence."[89] The 1957 Act had not survived its first test.

Dissatisfaction with the new law was widespread. The *Denver Post* branded the act "an admitted failure," and the chairman of the Colorado Ground Water Commission conceded it had "not been a very successful experience."[90] Other commentators were less reserved, claiming that the law was "futile and meaningless and shouldn't even have been approved."[91] Maurice Rosener, chairman of the Bijou Basin's locally elected board, pointed to "mistakes" by state administrators: "The people of the Bijou Creek area had the idea that the critical designation was being forced on them – that they had no voice in the designation," he said. In fact, the law's attempts to limit pumping actually produced the opposite effect, causing a flurry of well-drilling by farmers trying to beat the designation deadline.[92] By any measure, the 1957 Act proved ineffective as a tool for resource preservation.

But a subtle shift had occurred amid the jockeying, bravado, and threats preceding the act's passage. Beforehand, groundwater in the South Platte valley had been seen as a question of conservation; a discussion about how to best prolong the sustained use of a limited resource. But the political debate surrounding its regulation altered the prevailing

[88] "Controversy Looms Over Water Election," *Fort Morgan Times*, 6 March 1958.
[89] "Well Restrictions are Defeated," *Fort Morgan Times*, 11 March 1958.
[90] "State Admits Failure of Water Well Curbs," *Denver Post*, March 15, 1958; Cuykendall "Administration of Colorado Groundwater Law," undated, c1960.
[91] "Underground Water a Problem for State Control," *Denver Post*, December 20, 1964.
[92] "State Admits Failure of Water Well Curbs," *Denver Post*, March 15, 1958.

terms of the discussion. Groundwater had become "much more than a conservation issue," a newspaper editorial correctly observed.[93] Beforehand, discussions were framed primarily in the language of resource depletion, a focus inherent in the 1957 Act itself, summed up by a Bureau of Reclamation report as a "means of curtailing the overdevelopment of groundwater use."[94] But as arguments about the proposed legislation intensified, a new focus emerged: property rights. This issue had long been recognized by Code and others, but its importance had taken a back seat to overriding concerns about conservation. Now, the political debate was being reshaped.

As early as 1954, Sen. Ranger Rogers accused well users of "robbing" South Platte River.[95] Groundwater users fired back with property claims of their own: "Taking cubs away from a wild lioness would be a pleasure compared to trying to take water away from the farmers," one representative boasted.[96] Conceptually, groundwater users and surface rights holders were increasingly being partitioned – by administrators, lawmakers, and the media alike – into two opposing camps, each group presumably separate and clearly defined. Forgotten was the fact that many farmers still alternated between the two sources, or that both supplies constituted a common hydrolological resource. The physical presence of underground water was buried by a layer of abstraction, transforming a debate formerly about conservation into an argument preoccupied with property rights. The discussion concerning resource management was being reframed as a water war.

---

[93] "Underground Water Law Needed Now!" *Denver Post*, February 11, 1957.
[94] USBR Region 7 988, "South Platte River Basin Report," 1957, WGDC Box 17
[95] "Use of Underground Water Termed Threat to Streams," *Rocky Mountain News*, 17 December 1954.
[96] "Farmers, Ranchers Blast Plans to Regulate Underground Water," *Rocky Mountain News*, 7 February 1957.

Between superheated arguments, lawmakers struggled to address problems unresolved in 1957. "What we've certainly got to do is to decide once and for all who owns this ground water," said Felix Sparks, director of the Colorado Water Conservation Board. "Unless this is determined, we'll never get anywhere."[97] Most legislators favored some form of prior appropriation. A state advisory committee in 1959 concluded that the system was "too deeply imbedded in our fundamental law and in vested property rights for any sweeping changes to be made."[98] But groundwater strained the principles of this long-established system of allocating surface water. The key to prior appropriation was the call. If a senior right called for more water to fulfill its claim, upstream junior rights were cut off in sequence until the older right was satisfied. Since nearly all wells in the South Platte valley were newer than any reliable surface claim, a call would shut them down instantly under strict prior appropriation. At the same time, because of groundwater's extremely slow movement, cutting off a well was unlikely to provide more water to the calling surface-right until after the need had passed. Engineers such as Code recognized the "absurdities" such a system could cause. But with more than 9,000 irrigation wells statewide by 1960 – approximately 5,200 in the South Platte valley – the need for a workable law remained.[99]

Hydrological considerations found little room in the firestorm debate about property rights. Natural conditions fanned the flames. Regional droughts in 1962 and 1963 provoked accusations of "water-thievery,"[100] while local administrators urged

[97] "Ground Water Law Sought," *Denver Post*, 27 January 1965.
[98] David J. Miller and Samuel Chutkow, *Report on Ground Water Problems and Recommendations for Further Study and Legislative Consideration* (Denver: Department of Natural Resources and Colorado Water Conservation Board, 1960).
[99] "Need to Update Laws on Ground, Surface Water," *Business Farmer*, 12 October 1963.
[100] *Denver Post*, 10 August 1963.

farmers to "avoid panic…particularly the temptation to sink more wells without a prior integrated plan."[101] Meanwhile, more than two dozen ditch companies along the South Platte united to threaten litigation against groundwater users,[102] and the city of Boulder fired its "opening salvo" against well users by promising the same.[103] While the *Denver Post* lambasted groundwater users for their "appalling abuses,"[104] former governor Ed Johnson joined the fray, insisting that "instead of demagoguery about the naughty pumps, we ought to be on our knees thanking Divine Providence for this modern method of river water diversion."[105] One official summed up the situation as "virtual anarchy."[106] Following the rejection and revision of several legislative bills, the chaos finally culminated in the 1965 Ground Water Management Act.

This act settled the question of ownership. Groundwater was deemed public property under prior appropriation principles, but with certain modifications. The law sought to regulate groundwater conjunctively with surface rights, while simultaneously allowing for its "full economic development."[107] Recognizing that not all basins shared equal characteristics, lawmakers separated underground water into several categories. In relatively self-contained formations, such as the Ogallala beneath the state's eastern High Plains, groundwater was deemed "non-tributary," meaning it had no significant connection to any flowing river. This water was exempted from priority, allocated instead based on landownership. By contrast, alluvial groundwater – such as that of the South Platte valley – was considered "tributary," to be administered in priority by the State

[101] "Blair Urges Self-Restraint," *Denver Post*, 9 July 1963.
[102] "Action to Block Irrigation Wells Spreads," *Rocky Mountain News*, 11 December 1964.
[103] *Boulder Camera*, 26 September 1962.
[104] "Underground Water a Problem for State Control," *Denver Post*, 20 December 1964.
[105] "Big Ed Blasts Suggestions on Colorado Ground Water," *Rocky Mountain News*, 13 January 1965.
[106] "Ground Water Laws Sought," *Denver Post*, 27 January 1965.
[107] Ground Water Management Act, 1965 Colo. Sess. Laws, ch. 319.

Engineer in conjunction with established surface rights. But the act also contained provisions for creating "designated" groundwater basins, separately managed districts with local input within self-contained prior appropriation hierarchies. Lawmakers hoped that, by protecting surface rights and allowing for some economic development, they had at last put the state's groundwater problems to rest.

Opposition to the new measures did not materialize immediately, thanks to wet weather. In 1965, the South Platte River engulfed downtown Denver once again, causing upwards of $500 million in damages, but the heavy rains also doused any conflict over groundwater use.[108] Still, some experts predicted a "traumatic summer" for the new legislation if the weather changed.[109] Quickly, the Bijou Basin became part of the state's first Designated Groundwater Basin, accommodating the region that had wrecked the 1957 Act by authorizing significant local control and insulating the basin from competition with surface rights. But some analysts wondered how the law could be effective. Although the State Engineer was responsible for administering tributary groundwater and surface rights together, the statute offered no guidelines. Also questioned was the act's constitutionality, in terms of depriving landowners of property without due process.[110] Furthermore, silence on the status of existing wells created uncertainty among groundwater users and stifled loans for new equipment.[111] When the summer of 1966 proved to be exceptionally dry, the law was challenged for the first time.

[108] "In Earth: Liquid Gold," *Denver Post*, 18 July 1966.
[109] Raphael J. Moses and George Vranesh, "Colorado's New Ground Water Laws," *University of Colorado Law Review* 38 (1966): 295-310.
[110] Moses and Vranesh, 306.
[111] Colorado Legislative Council. *Implementation of 1965 Water Legislation*, Research Publication 114 (Denver: Colorado Legislative Council, 1966), xvi.

The test came from the Arkansas River, the South Platte's southern sibling. Although groundwater development in the South Platte basin was more extensive than along the Arkansas, both areas shared similar problems. In 1966, owners of senior surface rights placed a call on the Arkansas. Accordingly, the State Engineer's office ordered defendant Roger Fellhauer, whose 1935 well was drilled near the riverbed, to cease pumping. Fellhauer refused, but a district court approved the shutdown along with 38 other wells in the valley. But in 1968, the Colorado Supreme Court overturned the decision, ruling that the division engineer acted "arbitrarily and capriciously" by regulating only 39 of the valley's 1,600 or more irrigation wells without definite criteria. The division engineer protested that shutting down all junior wells would "affect the economy of the valley," adding that "we certainly can't just arbitrarily go in and shut off the water supply to a town." Nevertheless, the court's decision demonstrated difficulties of applying prior appropriation to groundwater. Justice James Groves' majority opinion was even more telling: "As administration of water approaches its second century," he wrote, "the curtain is opening upon the new drama of maximum utilization and how constitutionally that doctrine can be integrated into the law of vested rights."[112] In a single sentence, Groves crystallized the problem which would continue to vex Colorado into the next century.

But the drama of maximum utilization was not really new. Code and others had championed the cause when they called for resource management in order to prolong pumping. A new generation of groundwater scientists and engineers carried the banner into the 1960s. While newspapers and legislators traded barbs about property rights, and while farmers used overlapping water sources to sustain their crops, engineers began to

[112] *Fellhauer v. People,* 167 Colo. 320 (1968).

envision the South Platte valley aquifer as a form of quasi-bionic technology – a half-natural machine that could be manipulated and regulated for maximum productivity. Already humans had transformed the valley's dry gravels into a productive water-bearing resource; now researchers contemplated how to utilize that supply fully. As legislative revisions brewed in the state capitol, scientific perspectives would again meld and clash with visions of investments and property rights to shape accommodations between people and their environment.

Even before the *Fellhauer* decision, Colorado's general assembly had funded a full scientific study to examine the state's groundwater situation. One of the leading investigators was engineer Morton Bittinger, a professor at Colorado State University who, following Code, was among the state's top groundwater experts. Bittinger had also contributed similar studies before the 1965 Act, but according to one correspondent, these findings were "virtually ignored" by the law's drafting committee.[113] Bittinger's previous statements contained many of the same ideas he offered to the general assembly in 1968. He proposed "conjunctive management" as a way to maximize the valley's water, asserting that this system also provided "the only logical solution" to conflicts between groundwater use and surface-water rights.[114] Because of the intimate relationship between the South Platte River and its underlying aquifer, he advocated their management as a single supply.

Pointing to the aquifer's enormous storage capacity, Bittinger envisioned an underground reservoir that scientists could "manipulate" to achieve its full use. "If only one-fifth of this could be used for planned cyclical storage," he reported, "it would add

[113] "Underground Water a Problem for State Control," *Denver Post*, 20 December 1964.
[114] Morton Bittinger, "Colorado Ground Water Quiz," c1960. Box 15, GDC.

considerably to a total water plan for the system."[115] To accomplish this goal, the aquifer would be drafted heavily during dry cycles, and then artificially recharged during wet periods by transferring surface supplies underground.[116] He added that because the aquifer would not be constantly full, surface rights would at times need to be served from underground.[117] Bittinger sought to shape nature by using technology, but his vision also represented a much deeper relationship. The river basin had been transformed first through irrigation technology, opening the way to further technological exploitation by drills, pumps, and center-pivot sprinklers. But as the valley's natural idiosyncrasies caused property rights to become entangled, a new conception emerged – the aquifer itself as technology. Bristling with pumps, this nature-made reservoir could serve as a device for water management, much in the same manner as a human-built reservoir on the surface. By utilizing the river and its underlying aquifer in this way, Bittinger promoted a technology at once natural and artificial.

He was not alone in this vision. As early as 1952, engineer Royce Tipton had offered a similar plan of "intelligent coordination" to utilize groundwater more fully. As opposed to curtailing pumping to protect vested surface-water rights, Tipton advocated more wells, not fewer. "This is directly opposed to former thinking on the subject," he admitted,[118] explaining that temporarily lowering the water table by pumping was not necessarily negative: "No ground-water reservoir can be developed without mutual

[115] Morton Bittinger, "The Role of Ground-Water Reservoir Management in the Comprehensive Development of the Water Resources of the South Platte River Basin," in Miller and Chutkow.
[116] Basic artificial recharge was first employed in the South Platte basin in 1939, when the Henrylyn Irrigation District began intentionally filling a leaky reservoir in order to raise water levels in the Prospect Valley. This type of activity has grown considerably and is now practiced at many sites. See M. M. Skinner, "Water Resource Management in the Prospect Valley Area, Colorado," 1963. Box 13, GDC.
[117] "Problems of Conjunctive Use of Surface Water and Ground Water Supplies," 1963. Box 16, GDC.
[118] Royce J. Tipton to Judge Stone, 1952. MSS 312, Box 8, Stephen H. Hart Library, Colorado Historical Society.

interference of wells and in some cases without ultimate interference with the flow of some stream." Like Bittinger, he proposed that surface rights would be satisfied by wells during times of drought, which would ultimately achieve "the best use that could be made of the waters of the South Platte."[119] These ideas were hardly anathema within the scientific community. They were echoed by Robert Glover, whose 1968 *The Pumped Well* would become an accepted reference for determining the impact of groundwater extraction on stream flows. In 1959, he wrote that the "proper relationship" between groundwater and surface irrigation would be achieved by compensating surface rights with groundwater during times of drought. "It would be necessary," he wrote, "to pump the water table down to low levels if the drought were long continued," adding that groundwater and surface water actually complimented each other – surface diversions recharged the aquifer through irrigation seepage, while pumps prevented waterlogging of land, emptying the aquifer sufficiently to allow for floodwater storage.[120] Ultimately, each of these experts advocated more intensive manipulation of the South Platte's alluvial aquifer through increased pumping.

This use of groundwater as an underground reservoir had distinct advantages. Not only was the capacity of the South Platte valley-fill aquifer much greater than the basin's combined surface flows, but its water was also protected from evaporation. And unlike a surface reservoir, it was relatively insulated from erratic snowmelts from year to year. It was free from silting – the buildup of mud and sediment at a reservoir's bottom which gradually reduced storage capacity. Furthermore, construction costs were nonexistent, no

[119] Royce J. Tipton, "Technical Considerations in the Preparation of a Ground-Water Law," 1952. MSS 312, Box 8, Stephen H. Hart Library, Colorado Historical Society.
[120] Robert E. Glover to A.R. Chamberlain, 1959. Box 14, Papers of Robert E. Glover, Water Resources Archive, Colorado State University (hereafter REG).

inundation of farmland or towns was necessary, and no dams needed to be maintained. On the other hand, measuring the volume of water in an aquifer was more complicated than reading a single gage height in a surface reservoir, because groundwater levels were not the same in all locations. Also, because outflow occurred at many points instead of a single spillway, regulation would be more difficult. But perhaps the most daunting obstacle to an aquifer's technological regulation existed in human institutions and imaginations. "The biggest problem," Bittinger commented, "seems to be in getting a satisfactory marriage between the physical facts, which cannot be changed, and the existing legal, economic, social, and other institutional situations which resist change."[121] Likewise, Tipton felt compelled to urge legislators to keep their minds open, "without inhibitions due to former intimate and long-time association with the operation of the surface-water code."[122] Glover was equally concerned: "Much of the consideration has been devoted to the legal aspects of the case," he wrote, "with the result that the possibilities for constructive action have been ignored or forgotten."[123] The difference was one of perspective. Scientists and engineers tended to envision groundwater as a physical resource, something to be manipulated through technology, even as a technology itself. But to farmers and lawmakers, groundwater more often represented economic investment, or a tangled web of property rights administration and legal precedent. These visions competed to determine a course of action.

Each of these conflicting perspectives found some expression within the 1969 Water Rights Determination and Adjudication Act. The new law required tributary wells

[121] Morton Bittinger, "Comments on Papers Presented at the Ground Water Section of the Western Resources Conference," 1960, in Miller and Chutkow.
[122] Tipton to Stone, 1952. MSS 312, Box 8, Stephen H. Hart Library, Colorado Historical Society.
[123] Glover to Chamberlain, 1959. Box 14, REG.

to obtain legal priority dates, but it also allowed them to pump out-of-priority under certain conditions. In essence, the 1969 Act attempted to reconcile vested rights with proposition of maximum use. Retaining previously established categories of groundwater, it also introduced "augmentation," a provision allowing tributary wells to offset river depletions by finding replacement surface water to compensate senior rights. It also allowed surface rights to be served from "alternate points of diversion," including wells, if desired.[124] The law was an effort to integrate groundwater fully into the prior appropriation system while allowing enough flexibility for its continued use.

But the 1969 Act revealed the difficulties of reconciling scientific ideas of resource management with legal conceptions of property rights. Although Bittinger's findings were consulted in drafting the new legislation, his recommendations were "largely ignored," one state official commented.[125] Bittinger's report recommended that 10 to 15 percent of the groundwater beneath the South Platte be utilized, which would explicitly involve "a heavier draft upon the groundwater supplies during low runoff years." While the 1969 Act permitted augmentation plans to allow the sustained use of groundwater, such a provision essentially required the river, and hence the aquifer below, to remain full. And while the act allowed surface rights to fulfill their claims using wells, no incentives were offered to ease this transition. "This is legal integration," remarked Don Miles, Chairman of the State Water Liaison Committee, "but in no way does it provide for the physical integration or maximum utilization of our water resources."[126] Bittinger's conception of a technologically correlated whole did not translate easily into a system of established property rights.

[124] Water Rights Determination and Adjudication Act, 1969 Colo. Sess. Laws ch. 373.
[125] Don Miles, "Status of New Water Legislation," April 1969. Box 14, REG.
[126] Miles, "Status of New Water Legislation."

Other rifts between competing perspectives were evident as well. In the Bijou Basin, for example, farmers had injected their values into debates about groundwater, particularly in securing some local management and protection from competing surface-water rights. But other farmers were less fortunate. Glover especially criticized the discrimination between different types of groundwater within the South Platte alluvium. Physically, these distinctions did not necessarily exist. Every well, he pointed out, created a "cone of depression" – a circular depletion in the water table which radiated slowly outward, even after pumping stopped. All wells in the alluvium would deplete the river by their full consumption within five years: "If an aquifer…can be split," he argued, "then the well users in the 'immediate' portion would have to carry all of the burden of supplying water for calls from Senior appropriators."[127] Just as Bittinger's vision of the aquifer as a manageable technology did not fit precisely into a legal framework, neither did legal concepts necessarily correspond with hydrological considerations. Glover cautioned that the provisions of the 1969 Act "seem almost wholly concerned with man made laws and enactments. There seems to be little realization that these enactments could come into conflict with overriding natural laws."[128] While differing viewpoints found representation in the 1969 Act, they did not coexist quietly.

The legislation passed in 1969 seemed favored, for a time, by nature itself. More enduring than any other legal solution to Colorado's groundwater problems, it also benefited from the wettest twenty-year span in state history, from 1982 to 2002 [chk]. The law also worked tolerably well throughout the wet and dry cycles of the 1970s, though not without administrative problems. "One of the biggest headaches of my job

[127] Robert E. Glover to Fred E. Anderson, April 1971. Box 14, REG.
[128] "Comments by Robert E. Glover on the Tentative proposals for revision of Colorado's Water laws," c1969. Box 14, REG.

had always been getting water down to the senior irrigators along the South Platte," remembered State Engineer Kuiper. Often, when junior surface-water diversions were curtailed upstream, no water would arrive downstream to satisfy senior calls. "It was like the river had a great big hole in it."[129] The "hole" beneath the South Platte River was made by nature, consisting of thousands of years' worth of loosely composed sands and gravel. Early irrigators unintentionally filled it with water, and by the start of the twentieth century it fed the river's flow, which had grown stronger on top of it. Irrigators claimed these added volumes, expanding the accommodation between water use and availability. When drought unexpectedly disrupted this situation, farmers were inspired to tap the aquifer with new technologies – drills, pumps, new fuels, and electricity. When the drought lifted, groundwater use continued. The amount of irrigated acreage in northeastern Colorado increased, stretching the accommodation even further. When declining water tables threatened to upset this tentative balance, scientists began to see groundwater as a vulnerable resource, requiring preservation and careful management. But to farmers, it was a form of economic investment, and its use continued and even accelerated. This activity threatened property rights built on the river's increased flow, and new droughts inflamed the conflict. Ultimately, groundwater legislation in the 1960s struggled to preserve not a natural state, but rather a half-natural accommodation between water use and availability – a full river and the continuing use of groundwater. When severe drought returned in 2002, however, these twin goals again became difficult to reconcile.

[129] Kuiper's quote appears in Marc Riesner's *Cadillac Desert: The American West and its Disappearing Water* (New York: Viking, 1986), 444.

Legal provisions designed to preserve a particular level of accommodation became shackles when confronted by nature's unpredictability. Old water doctrines were turned inside-out. Following the drought of 2002, a research team from Colorado State University found that farmers reliant on established surface-water rights exited agriculture at a higher rate than groundwater users, whose junior supplies were less immediately vulnerable to reduced rainfall. This situation, noted the researchers, was "exactly counter to the way appropriative water rights are designed to operate in Colorado."[130] Yet when this incongruity was corrected through tighter administration, the principle of maximum utilization was impeded.[131] Because surface rights were established before groundwater rights, rigid administration threatened to prohibit groundwater use whenever surface flow decreased. In this way, prior appropriation – long an author of economic development in the West – was turned on its head by groundwater, becoming a hindrance to its economical use. The laws of 1965 and 1969 were replete with attempts to "soften" prior appropriation in order to permit groundwater extraction. In addition, prior appropriation was especially likely to interfere with pumping during times of shortage, precisely when a reserve supply of water would be most necessary. This scenario was partly realized in 2006, when some farmers in the valley were forced to watch their crops burn in the sun, even though a vast underground reservoir remained physically available beneath their feet.[132] These contradictions continue to test the

[130] Frasier and Schuck, "Coping with Natural and Institutional Drought."
[131] In 2003, the Colorado Supreme Court upheld a ruling that the State Engineer lacked sufficient authority to approve annual augmentation plans. *Moyer v. Empire Lodge Homeowners Association*, 78 Colo. 313 (2003).
[132] The state-mandated 2006 shutdown of some 440 wells in northeastern Colorado generated ongoing media attention. For an introduction see Will Shoemaker, "Wilting away: Northern Colorado farmers say it's getting harder and harder to farm," *Brighton Standard/Blade*, 8 November 2006.

ingenuity and fortitude of scientists, farmers, and lawmakers alike, much as they have for more than half a century.

Additional issues, some of which are rapidly developing, will likely contribute new historical insights over time. For example, the post-1969 legal, scientific, and administrative acrobatics necessary to promote out-of-priority well use and groundwater recharge programs deserve stories of their own. Also, connections between groundwater use and water quality, wildlife, and recreation still need to be more fully explored, as do potential complications caused by interstate river compacts. Perhaps most important, however, is the unfolding issue of urban population growth in the West. As more and more people strain the delicate accommodations between water use and availability – and as water continues to be transferred from agricultural to municipal purposes – it seems unlikely that renewable groundwater will be ignored as a valuable source of supply. Perhaps the most significant changes are still to come.

Ultimately, groundwater use in the South Platte valley illustrates not only the conflicting perspectives that shape our interactions with nature, but also the ways in which people and natural forces are interconnected. This complexity requires recognition of water itself as an active historical element. Water, weather, and the natural qualities of the South Platte valley aquifer coauthored the changes. Inseparable, both human and non-human influences merged to create the valley's greater environment. At times, these entwined forces complemented one another to create the appearance of stability between resource use and availability. Yet in actuality, these illusory periods of accommodation indicated a delicate interplay among numerous and manifold influences.

As a whole, this story can help explain how the chaos of nature can seem stable, at least for a time. In a world made by humans and nature together, tentative balances can be tipped by forces beyond our control, but also tilted by our own actions and perspectives. Collectively, although we cannot predict the future, humans play a role in determining what shape our environments may take. We have choices in deciding which types of accommodation are worth trying to preserve. The environment will respond to our influences no matter what we choose, although not necessarily in ways we expect. This recognition can help ensure that we at least make these decisions consciously. In the meantime, as people in Colorado and throughout the West hope for rain, water moves underground.

Bibliography

Aikin, Andrea, et al., eds. *Colorado Ground-Water Atlas.* Lakewood: Colorado Ground-Water Association, 2000.

Ashley, Jeffery S., and Zachary A. Smith. *Groundwater Management in the West*. Lincoln: University of Nebraska Press, 1999.

Bash, P.K., and R.A. Young. *The Role of Tributary Ground Water in Irrigated Crop Production in the South Platte Basin: Results from a Survey.* Fort Collins: Colorado Water Resources Research Institute, 1994.

Bittinger, Morton W. "Comprehensive Development of River Basin Water Resources." *Colorado Farm and Home Research* 12, no. 4 (January-February 1962): 3-7.

Bjorklund, L.J., and R.F. Brown. *Geology and Ground-Water Resources of the Lower South Platte River Valley between Hardin Colorado, and Paxton Nebraska.* Washington, D.C.: GPO, 1957.

Boulder Camera. 1962

Bowden, Charles. *Killing the Hidden Waters.* Austin: University of Texas Press, 1977.

Brighton Standard Blade. 2006.

Carpenter, L.G. *Seepage or Return Waters from Irrigation.* The State Agricultural College Experiment Station, Bulletin 33. Fort Collins: Colorado Agricultural College, January 1896.

Cech, Tomas V., and Andy Jones. *Colorado Water Law for Non-Lawyers*. unpublished manuscript in possession of the author.

Cech, Tomas V. "Ground Water Issues in the South Platte Basin." *Colorado Water* (April 2004).

_____. *Principles of Water Resources: History, Development, Management, and Policy.* John Wiley & Sons, Inc., 2005.

_____. "Water Development and Management along the South Platte River of Colorado." In *Water and Climate in the Western United States*, edited by William M. Lewis, Jr. Boulder, University of Colorado Press, 2003.

Code, W.E. *Colorado Needs Ground-Water Legislation*. Fort Collins: Colorado A & M College, 1954.

_____. *Use of Ground Water for Irrigation in the South Platte Valley of Colorado.* Colorado Agricultural Experiment Station, Bulletin 483. Fort Collins: Colorado State College, September 1943.

Colorado Bar Association. *Retrospective of the Water Right Determination and Administration Act of 1969*. Denver: Continuing Legal Education in Colorado, Inc., 2003.

Colorado Legislative Council. *Implementation of 1965 Water Legislation,* Research Publication 114. Denver: Colorado Legislative Council, 1966.

Colorado Rancher and Farmer. 1955.

Colorado Rural Electric News. 1953, 1955, 1963.

Colorado State University Extension Collection. University Archive, Colorado State University.

Connaughton, Charles A. *The Water Resources of Colorado.* U.S Department of Agriculture, 1937.

Cronon, William. *Nature's Metropolis: Chicago and the Great West*, New York: Norton, 1991.

_____. "A Place for Stories: Nature, History, and Narrative." *Journal of American History* 78 (March 1998): 1347-1376.

_____. "The Trouble With Wilderness; or, Getting Back to the Wrong Nature." *Environmental History* 1 (January 1996): 7-28.

_____, ed. *Uncommon Ground: Toward Reinventing Nature*. New York: W.W. Norton, 1995.

_____. "The Uses of Environmental History." *Environmental History Review* 17 (Fall, 1993): 1-22.

Cunfer, Geoff. *On the Great Plains*. College Station: Texas A&M University Press, 2005.

Debler, E.B. "Return Flow and Its Problems on Reclamation Projects." *New Reclamation Era* (August 1927).

Denver Post. 1954-1958, 1964-1969

Dille, J. M. *Irrigation in Morgan County*. Fort Morgan: Farmers State Bank, 1960.

Dunbar, Robert G. “The Adaptation of Groundwater Control Institutions to the Arid West.” *Agricultural History* 51 (1977): 662-680.

_____. *Forging New Rights in Western Waters*. Lincoln: University of Nebraska Press, 1983.

Farmer, Edward J. *Colorado’s Ground Water Problems: Water and the Law*. Colorado State University Experiment Station, Bulletin 505-S. Fort Collins: Colorado State University, January 1960.

_____. “A Study of the Effect of Ground Water Law on Pumping in the Bijou Bain.” M.A. thesis, Colorado State University, 1960.

Fellhauer v. People, 167 Colo. 320, 1968.

Fiege, Mark. “Creating a Hybrid Landscape: Irrigated Agriculture in Idaho.” *Illahee: Journal for the Northwest Environment* 11 (Spring/Summer 1995): 60-76.

_____. *Irrigated Eden: The Making of an Agricultural Landscape in the American West.* Seattle: University of Washington Press, 1999.

Fort Collins Coloradoan. 1953, 1956-1958, 1964, 1966, 2003

Fort Morgan Times. 1955, 1958

Frasier, Marshall, and Schuck, Eric. “Coping with Natural and Institutional Drought.” *Current Agriculture, Food & Resource Issues* 5 (2004): 119-130.

Getches, David H. *Water Law in a Nutshell*. 3rd ed. St. Paul, Minn.: West Pub. Co., 1997.

Greeley Tribune. 1955, 2007

Green, Donald E. *Land of the Underground Rain: Irrigation on the Texas High Plains, 1910-1970.* Austin: University of Texas Press, 1973.

Groundwater Data Collection. Water Resources Archive, Colorado State University.

Hardin, Garrett. “The Tragedy of the Commons.” *Science* 162 (Dec. 1968): 1244.

Hobbs, Gregory J., Jr. “Colorado and Western Water Law: A Continuing Alchemy.” *The Water Report* 36 (February 2007).

_____. “Colorado’s 1969 Adjudication and Administration Act: Settling In.” *University of Denver Water Law Review* (Fall 1999).

_____. “Colorado Water Law: An Historical Overview.” *University of Denver Water Law Review* (Fall 1997).

_____. “The Role of Climate in Shaping Western Water Institutions.” *University of Denver Water Law Review* (Fall 2003).

Hughes, Thomas P. *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970.* New York: Viking, 1989.

_____. *Human-Built World: How to Think about Technology and Culture.* Chicago: University of Chicago Press, 2004.

_____. *Networks of Power: Electrification in Western Society, 1880-1930*. Baltimore: The Johns Hopkins University Press, 1983.

Hundley, Norris Jr. *The Great Thirst: Californians and Water: A History*. Rev. ed. Berkeley: University of California Press, 2001.

_____. “Water and the West in Historical Imagination.” *Western Historical Quarterly* 27, no. 1 (Spring 1996): 4-31.

Igler, David. “When is a River Not a River? Reclaiming Nature’s Disorder in *Lux v. Haggin*.” *Environmental History* 1, no. 2 (April 1996): 52-69.

Jackson, Donald C. *Building the Ultimate Dam: John S. Eastwood and the Control of Water in the West.* Lawrence: University Press of Kansas, 1995.

Kahrl, William L. *Water and Power: The Conflict Over Los Angeles' Water Supply in the Owens Valley*. Berkeley: University of California Press, 1982.

Langston, Nancy. *Where Land and Water Meet: A Western Landscape Transformed.* Seattle: University of Washington Press, 2003.

Lewis, William M., Jr. *Water and Climate in the Western United States.* Boulder: University of Colorado Press, 2003.

MacDonnell, Lawrence J. “Colorado’s Law of Underground Water: A Look at the South Platte Basin and Beyond.” *University of Colorado Law Review* 59, no. 3 (Summer 1988): 579-625.

_____. *Integrating Tributary Groundwater into the Prior Appropriation System: The South Platte Experience.* Fort Collins: Colorado Water Resources Research Institute, 1988.

_____, ed. *Tradition, Innovation and Conflict: Perspectives on Colorado Water Law.* Boulder: Natural Resources Law Center, University of Colorado School of Law. 1986.

McClellan v. Hurdle, 3 Colo. App. 430, 1893.

McEvoy, Arthur. "Toward an Interactive Theory of Nature and Culture: Ecology, Production, and Cognition in the California Fishing Industry." *Environmental Review* 11 (Winter 1987): 289-305.

McKee, Thomas B., Nolan J. Doesken, and John Kleist. *A History of Drought in Colorado: Lessons Learned and What Lies Ahead.* Fort Collins: Colorado Water Resources Research Institute, 2000.

Michener, James A. *Centennial.* New York: Random House, 1974.

Miller, David J., and Samuel Chutkow. *Report on Ground Water Problems and Recommendations for Further Study and Legislative Consideration.* Denver: Department of Natural Resources and Colorado Water Conservation Board, 1960.

Morgan County Agricultural Planning Committee. *Good Farming Practices in Morgan County*. Fort Morgan: County Extension Office, 1944.

Moses, Raphael J. and George Vranesh. "Colorado's New Ground Water Laws." *University of Colorado Law Review* 38 (1966): 295-310.

Moyer v. Empire Lodge Homeowners Association, 78 Colo. 313, 2003.

Nash, Linda. "The Changing Experience of Nature: Historical Encounters with a Northwest River." *The Journal of American History* 86, no. 4 (March 2000): 1600-1629.

Opie, John. *Ogallalla: Water for a Dry Land.* Lincoln: University of Nebraska Press, 1993.

Orsi, Jared. *Hazardous Metropolis: Flooding and Urban Ecology in Los Angeles.* Berkely: University of California Press, 2004.

Papers of Delph E. Carpenter and Family. Water Resources Archive, Colorado State University.

Papers of M.C. Hinderlider. MSS 312, Colorado Historical Society.

Papers of Robert E. Glover. Water Resources Archive, Colorado State University.

Perkin, Robert L. *The First Hundred Years: An Informal History of Denver and the Rocky Mountain News.* New York: Doubleday & Company, Inc. 1959.

Pisani, Donald J. "Enterprise and Equity: A Critique of Western Water Law in the Nineteenth Century." *The Western Historical Quarterly* 18, no. 1 (January 1987): 15-37.

_____. *Water, Land, and Law in the West: The Limits of Public Policy, 1850-1920.* Lawrence: University Press of Kansas, 1996.

Price, Jennifer. "Looking for Nature at the Mall: A Field Guide to the Nature Company." In *Uncommon Ground: Toward Reinventing Nature*, edited by William Cronon. New York: W.W. Norton, 1995.

Pritchett, James and Stephan Weiler. "Estimated Economic Impact of Well Depletions by the Groundwater Appropriators of the South Platte (GASP)." *Agricultural and Resource Policy Report*, Colorado State University, Department of Agricultural and Resource Economics (January 2003).

Pueblo Chieftan. 1954.

Records of GASP. Water Resources Archive, Colorado State University.

Reisner, Marc. *Cadillac Desert: The American West and its Disappearing Water*. New York: Viking, 1986.

Rocky Mountain News. 1954, 1957, 1963-1965.

"A Round Table: Environmental History." *Journal of American History* 76 (March 1990): 1087-1147.

Rothman, Hal K. "Water and the Western Service Economy: A New Challenge." In *Fluid Arguments*, edited by Char Miller. Tucson: University of Arizona Press, 2001.

Safranek v. Town of Limon, 123 Colo. 330, 1951.

Scott, James C. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven: Yale University Press, 1998.

Sherow, James Earl. *Watering the Valley: Development along the High Plains Arkansas River, 1870-1950*. Lawrence: University Press of Kansas, 1990.

Silkensen, Greg M. "South Platte River Observations: Historical Clues to the Evolution of a River's Ecology." *Colorado Water* (1992).

Slattery, Harry. *Rural America Lights Up: The Story of Rural Electrification.* Washington: National Home Library Foundation, 1940.

Steinberg, Theodore. *Slide Mountain, or the Folly of Owning Nature.* Berkeley: University of California Press, 1995.

Stenzel, Dick. "Wells: The Final Frontier." Colorado Water (December 2006).

Summers, Gregory. *Consuming Nature: Environmentalism in the Fox River Valley, 1850-1950.* Lawrence: University of Kansas Press, 2006.

Summers, Thos. H., *An Agricultural Program for the Irrigated Region of Northern Colorado*. Fort Collins: Colorado Agricultural College Extension Service, 1930.

Trout Unlimited. *Gone to the Well Once Too Often: The Importance of Ground Water to Rivers in the West.* Trout Unlimited, Western Water Project, 2007.

Tyler, Daniel. *The Last Water Hole in the West: The Colorado-Big Thompson Project and the Northern Colorado Water Conservancy District*. Niwot, Colo.: University Press of Colorado, 1992.

_____. *Silver Fox of the Rockies: Delphus E. Carpenter and Western Water Compacts.* Norman: University of Oklahoma Press, 2003.

U.S. Environmental Protection Agency. *The South Platte River in Colorado.* Washington: U.S. Department of Agriculture, 1999.

U.S. Water News Online. 2002

Vranesh, George. *Vranesh's Colorado Water Law*. Edited by James N. Corbridge and Teresa A. Rice. Niwot, Colo.: University Press of Colorado, 1999.

Walton, John. *Western Times and Water Wars: State, Culture, and Rebellion in California.* Berkeley: University of California Press, 1992.

Warren, Louis S. *The Hunter's Game: Poachers and Conservationists in Twentieth-Century America*. New Haven: Yale University Press, 1997.

Webb, Walter Prescott. *The Great Plains.* New York: Grosset and Dunlap, 1931.

Wescoat, James L., Jr. "On Water Conservation and Reform of the Prior Appropriation Doctrine in Colorado." *Economic Geography* 61, no. 1 (Jan. 1985): 3-24.

West, Elliott. *The Contested Plains: Indians, Goldseekers, and the Rush to Colorado.* Lawrence: University of Kansas Press, 1998.

The Western Farm Life. 1929, 1937-1938, 1947-1948.

White, Richard. "'Are You and Environmentalist or Do You Work for a Living?': Work and Nature." In *Uncommon Ground: Toward Reinventing Nature*, edited by William Cronon. New York: W.W. Norton, 1995.

_____. *The Organic Machine: The Remaking of the Columbia River*. New York: Hill and Wang, 1995.

Worster, Donald. *Rivers of Empire: Water, Aridity, and the Growth of the American West*. New York: Pantheon Books, 1985.

_____. *The Wealth of Nature: Environmental History and the Ecological Imagination*. New York: Oxford University Press, 1993.

Wyman, Walker D. *Witching for Water, Oil, Pipes, and Precious Metals: A Persistent Folk Belief from Frontier Days Down to the Present*. River Falls: University of Wisconsin Press, 1977.